

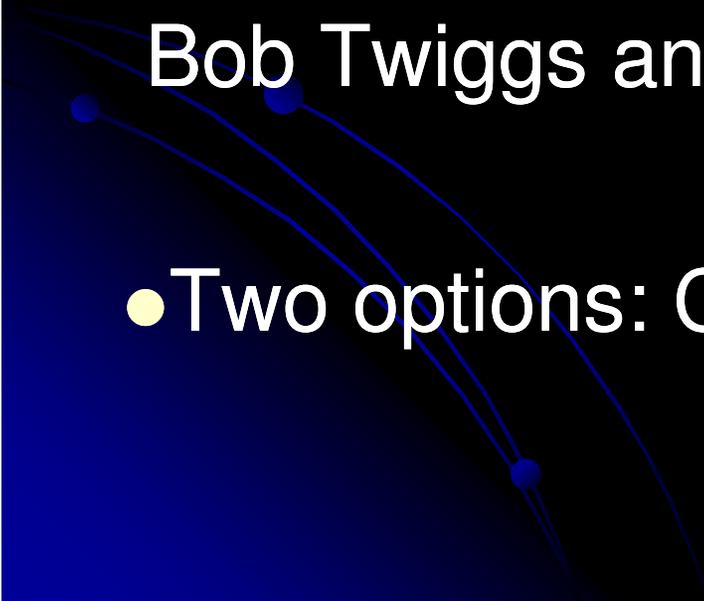
Design and Flight Testing of the ARLISS Rocket and CFD Modeling of the Nosecone Region



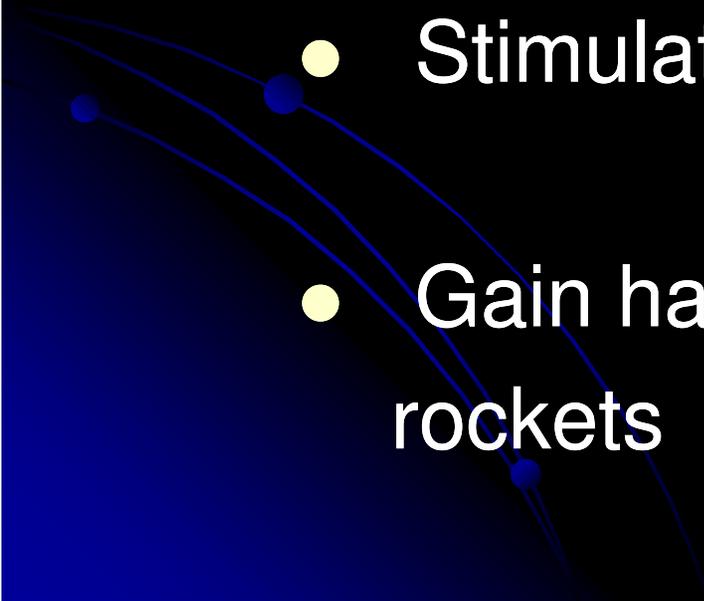
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Patricia Nerio
Austin Epps
Dr. P. Papadopoulos

Special Thanks to
Tom Rouse,
Rocketeer

What is Arliss?

- A Rocket Launch for International Students Satellites.
 - Organization started in 1999 by Professor Bob Twiggs and AeroPac members.
 - Two options: CanSat or ComeBack.
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Why Arliss?

- Provides learning experience for all students
 - Stimulates interests in Rocketry
 - Gain hands on experience with rockets
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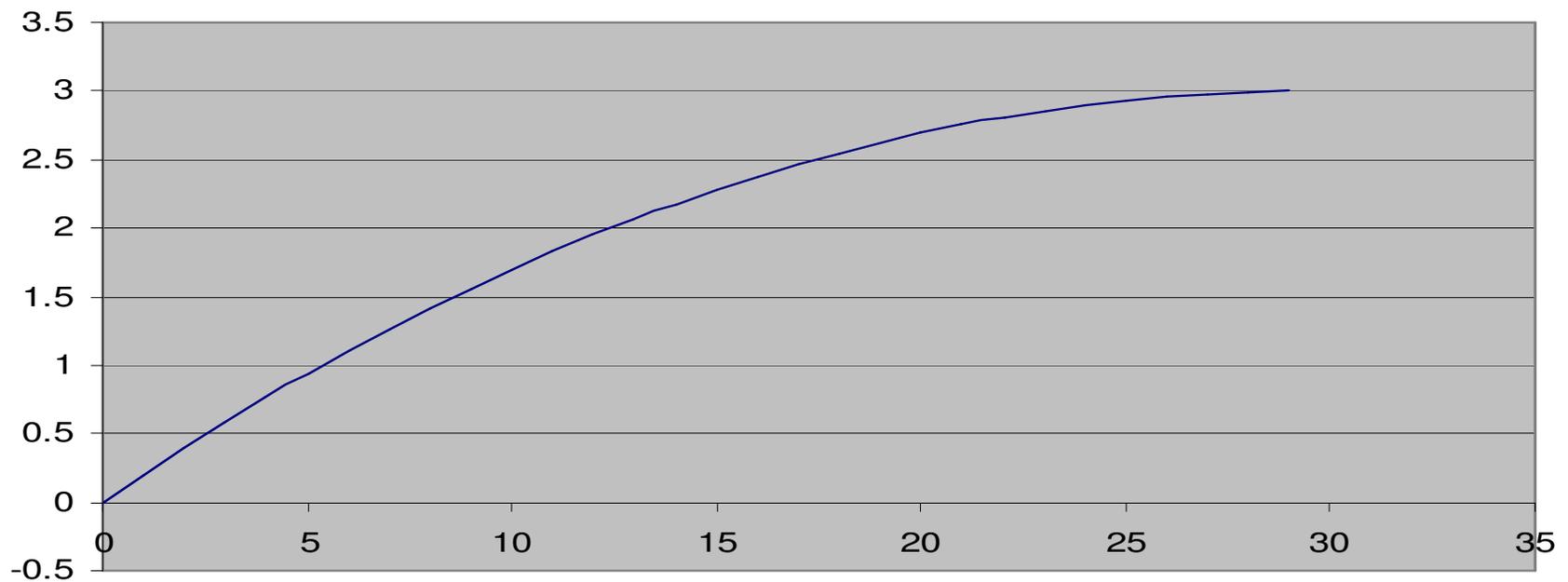
Approach

- Various nose cone profiles were studied and analyzed using CFD.
- Detailed CFD modeling and analysis was done for tangent ogive nose cone.
- Rocket was designed using Rocksim.
- Rocket was built and tested. Flight data was recorded and compared with CFD and Rocksim simulations.

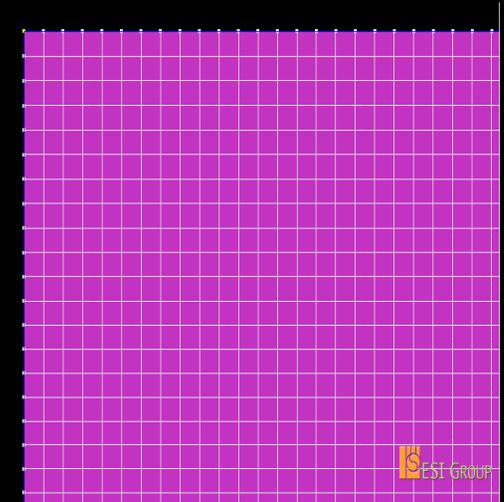
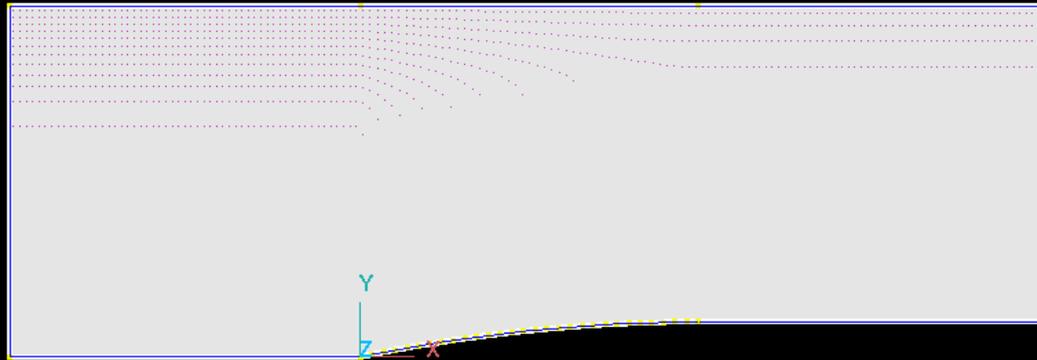
CFD Analysis

- 2-D Axisymmetry model

Tangent ogive nose cone profile



Grid Modeling

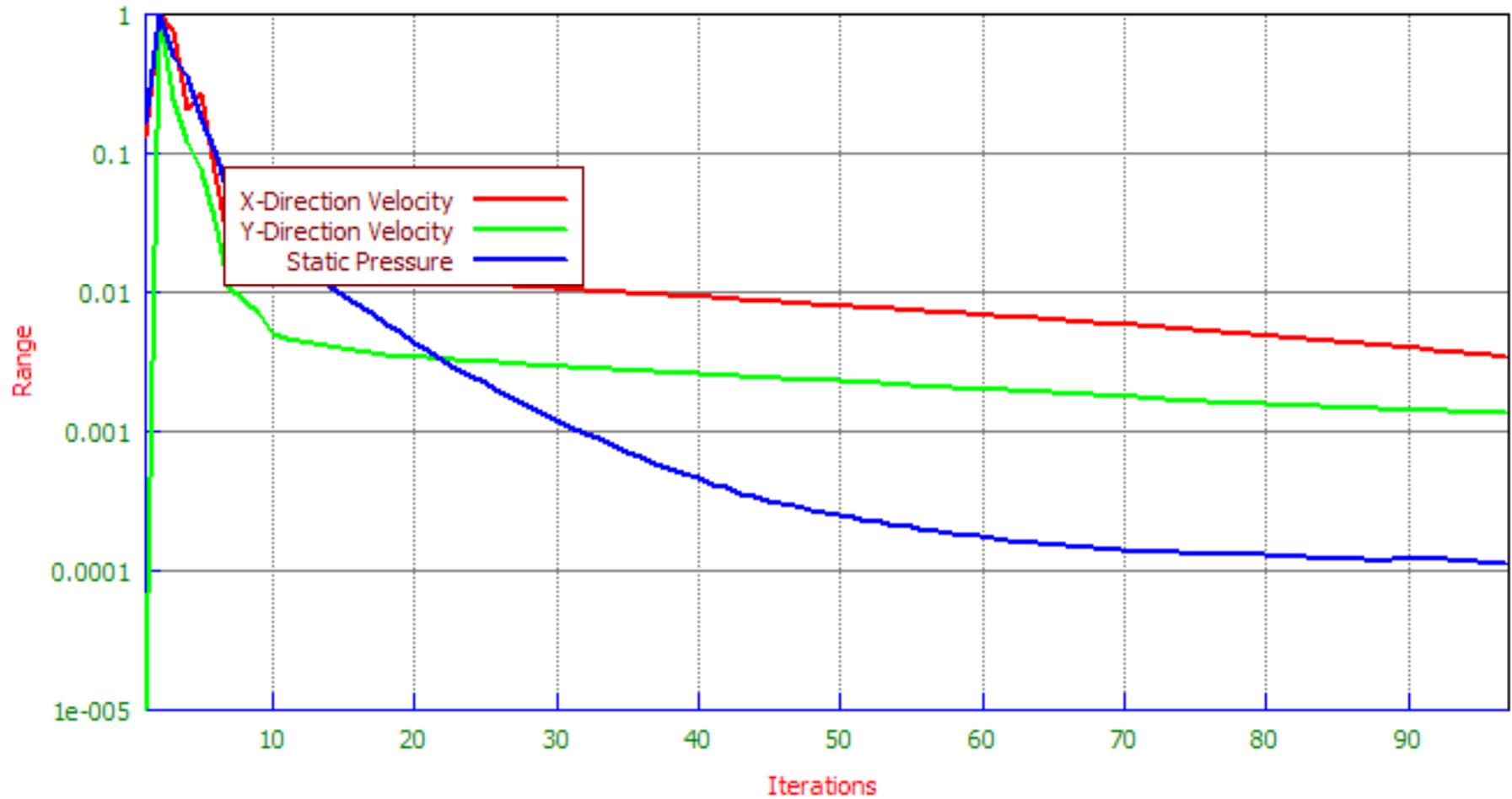


- No of cells: 238203
- Smallest Volume: $4.386218E-14$
- Largest Volume: $1.110289E-05$
- Smallest Angle : 32.20°



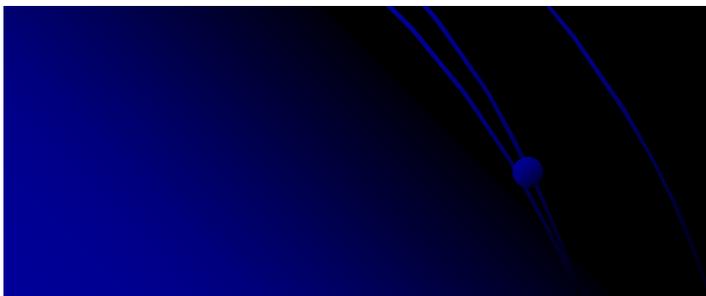
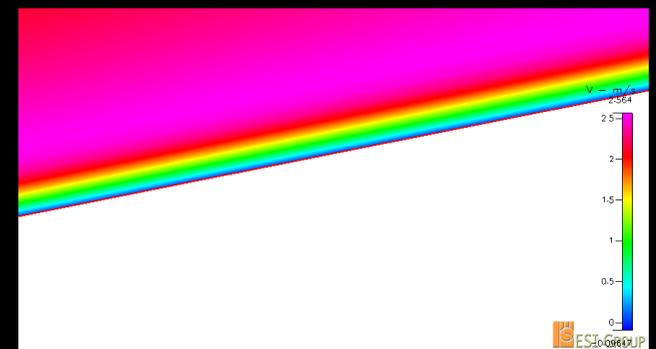
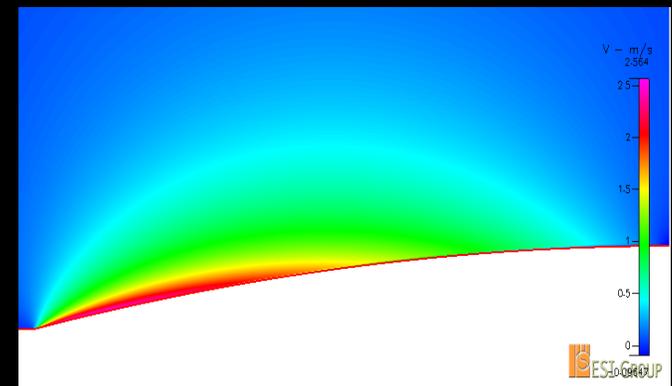
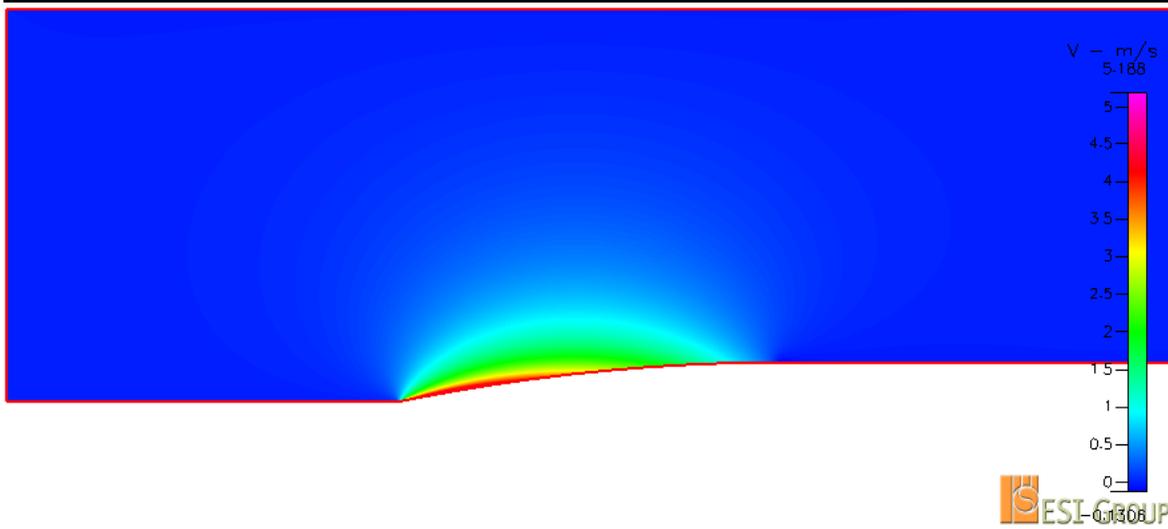
Results

Residual Plot

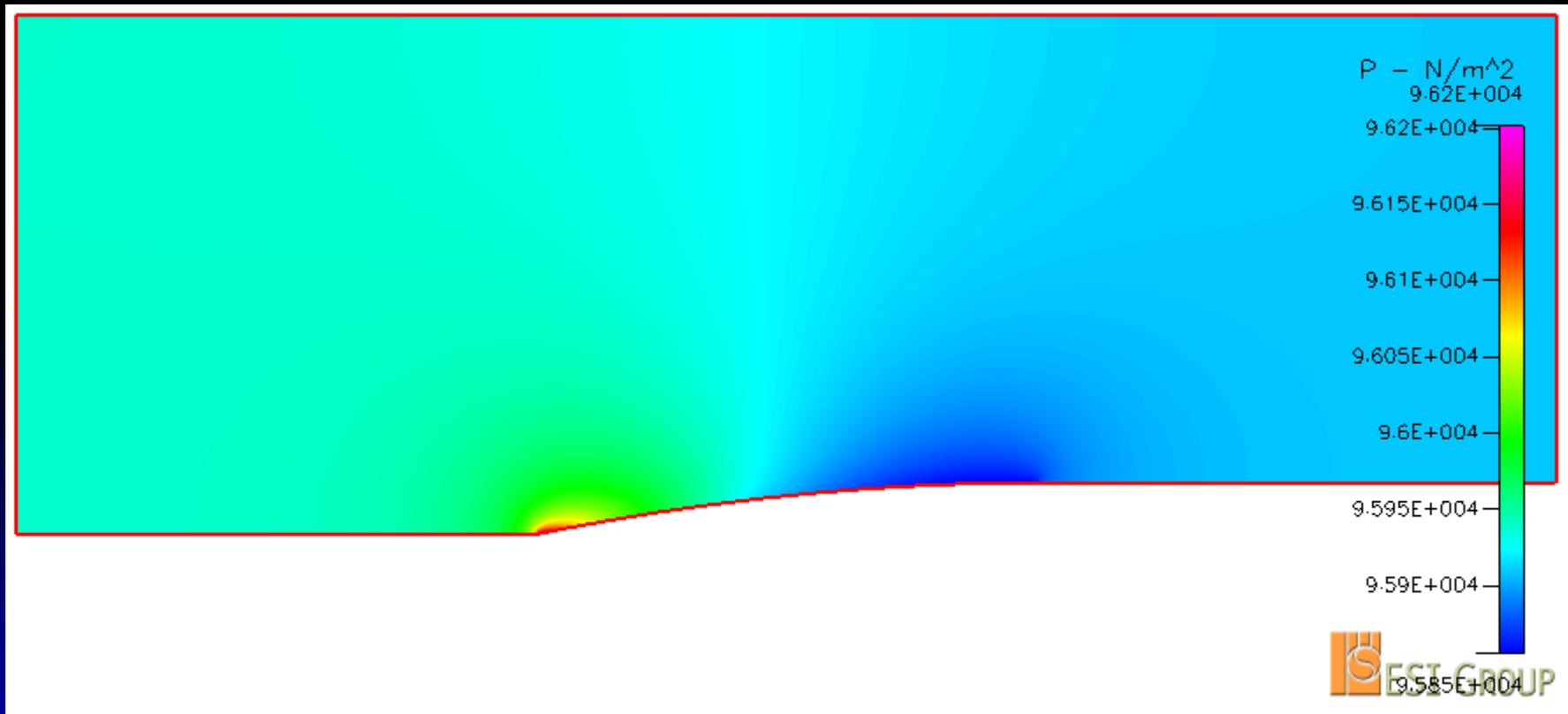


Screen Shots

Velocity Distribution

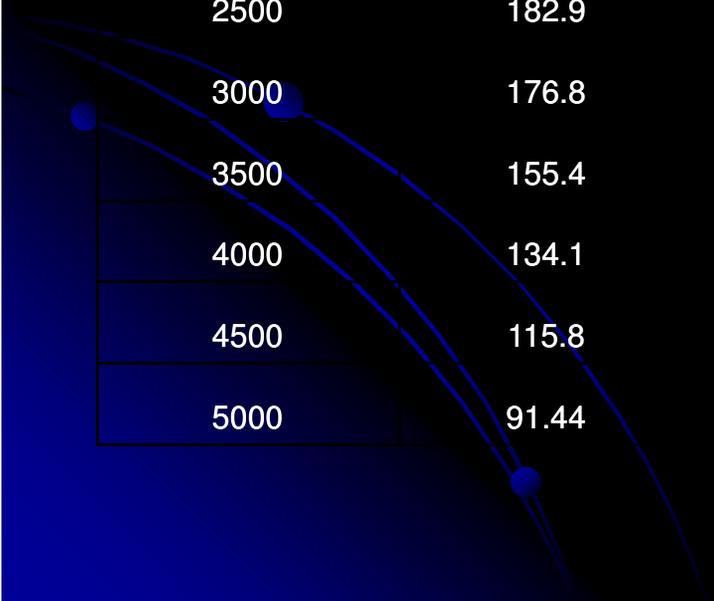


Pressure Distribution



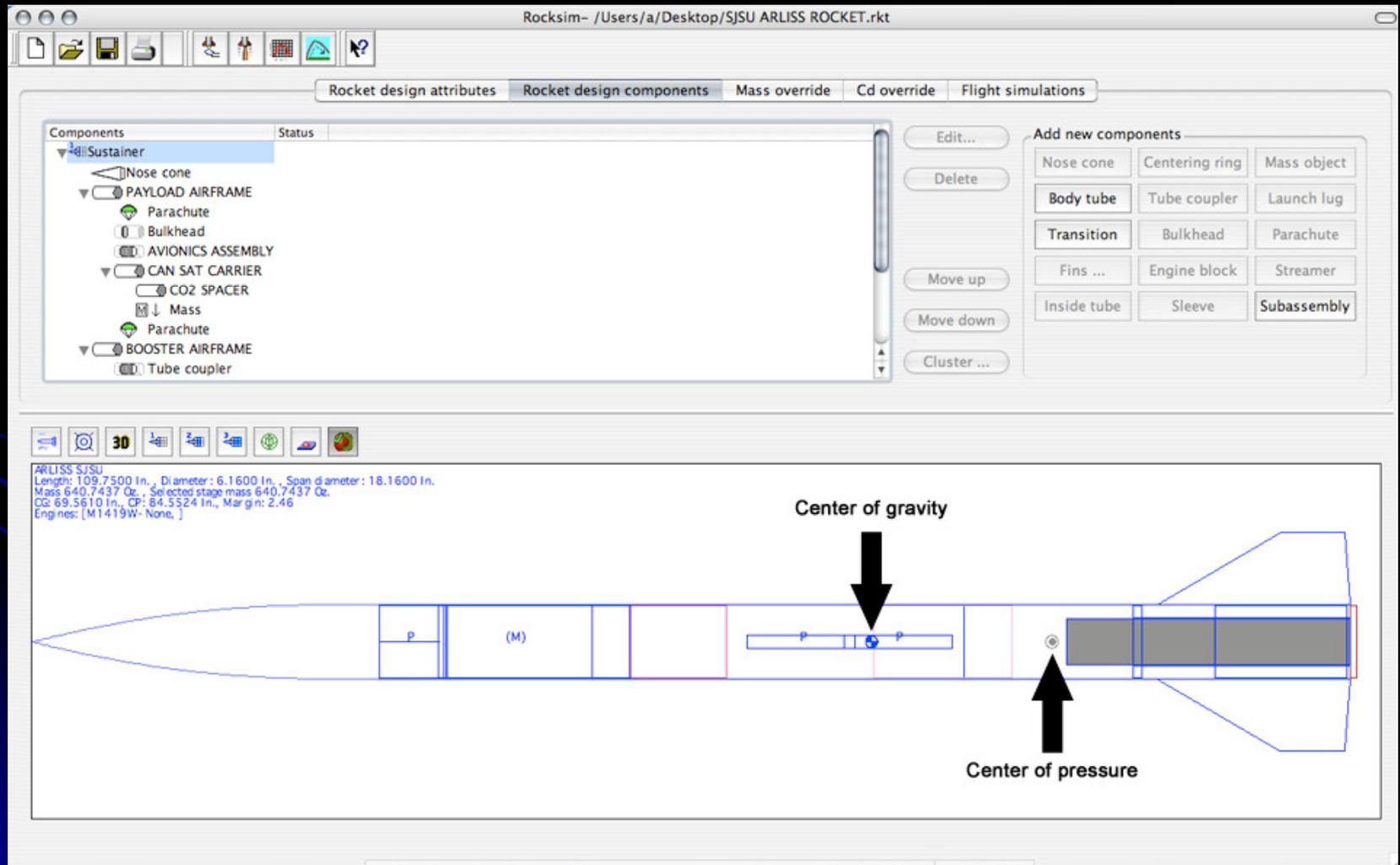
Results cont.

ALTITUDE (Feets)	VELOCITY (m/s)	PRESSURE (Pa)	DRAG (N)	DENSITY (Kg/m³)	Cd
500	134.1	768.01	13.9418	1.207171805	<i>0.070757</i>
1000	152.4	756.79	13.73812	1.18954585	<i>0.054784</i>
1500	184.4	749.76	13.6105	1.172126046	<i>0.037623</i>
2000	195	744.4	13.5132	1.154912393	<i>0.033901</i>
2500	182.9	722.96	13.124	1.137904892	<i>0.037985</i>
3000	176.8	709.36	12.87711	1.121052005	<i>0.040486</i>
3500	155.4	692.71	12.57486	1.104405269	<i>0.051946</i>
4000	134.1	676.6	12.28242	1.087964685	<i>0.069166</i>
4500	115.8	661.99	12.0172	1.071678714	<i>0.09213</i>
5000	91.44	647.12	11.74726	1.055598895	<i>0.146637</i>



RockSim

- Software to design model rockets and simulate their flights.
Step 1: Choose or design components, then assemble them to create the rocket.



RockSim

Step 2: Choose an engine and set launch conditions.

The screenshot displays the RockSim software interface. The main window, titled "Rocksim simulation properties", has several tabs: "Engine selection", "Flight events", "Simulation controls", "Starting state", "Launch conditions", and "Competition settings". The "Launch conditions" tab is active, showing various environmental parameters such as Altitude (0.00000 Ft.), % Relative humidity (50.00), Temperature (59.00 Deg. F), Barometric pressure (1.013 Bar), Latitude (0.000 Deg.), Wind conditions (Slightly breezy (8-14 MPH)), Low wind speed (8.0000 MPH), High wind speed (14.9000 MPH), Wind turbulence (Fairly constant speed (0.01)), Wind change frequency (0.0100), and Wind starts at altitude (0.00000 Ft.).

Overlaid on this is a "Rocksim - engine selections" dialog box. It features a "Motor mount" field set to "98.0 mm - M1419W-None" and a "Manufacturer filter" dropdown. The "Diameter filter" is set to "Show only engines that match the mount diameter." Below this is a table of engine options:

	Mfg. name	Engine code	Diameter mm	Length In.	Burn Sec.	Total impulse N-Sec.
0	Aerotech	K458W	98.00	10.8268	6.40	2560.013
1	Aerotech	K650T	98.00	11.3780	4.11	2387.849
2	Aerotech	K680R	98.00	11.3780	3.49	2358.340
3	Aerotech	K1999N	98.00	11.3780	1.40	2520.394
4	Aerotech	L952W	98.00	17.4409	6.70	5097.920
5	Aerotech	L1300R	98.00	17.4409	3.50	4556.421
6	Aerotech	M1419W	98.00	23.5039	7.00	7582.664
7	Aerotech	M1600R	98.00	22.7953	4.50	6993.198
8	Aerotech	M1939W	98.00	29.5669	7.00	10339.815
9	Aerotech	M2000R	98.00	28.8189	4.70	9181.044
10	Aerotech	M2400T	98.00	23.5039	3.50	7619.763
11	Aerotech	M2500T	98.00	29.5669	4.26	9572.996
12	Aerotech	M845HW	98.00	31.3000	7.50	6601.600

Below the table, there are fields for "Ejection delay in seconds" (set to None), "Ignition delay in seconds" (set to 0.00), and "Engine overhang" (set to 0.0197 In.). The dialog box includes "Help", "OK", and "Cancel" buttons.

RockSim

Step 3: Run simulation.

Rocksim- /Users/a/Desktop/SJSU ARLISS ROCKET.rkt

Rocket design attributes Rocket design components Mass override Cd override Flight simulations

Simulation	Results	Engines loaded	Max. altitude Feet	Max. velocity Feet / Sec	Max. acceleration Feet/sec/sec	Time to apogee	Velocity at deploy Feet / Sec	Altitude at deploy Feet
5	4	[M1419W-None]	11190.22	1003.75	232.39	25.38	8.13	11190.22
6	5	[M1419W-None]	10281.04	969.63	227.81	24.13	6.83	10281.04
7	6	[M1419W-None]	10690.12	987.43	230.17	24.69	33.18	10690.12
8	7	[M1419W-None]	9504.46	937.16	223.81	23.05	13.47	9504.46
9	8	[M1419W-None]	13399.64	1069.07	240.66	28.33	8.43	13399.64
10	9	[L952W-30]	8992.32	783.54	186.48	24.41	11.72	8992.32
11	10	[L952W-30]	8962.30	783.50	186.56	24.37	35.13	8962.30
12	11	[M1419W-None]	12431.04	1048.83	237.80	27.04	67.40	12431.04
13	12	[L952W-None]	8282.28	767.04	183.43	23.28	75.39	8282.28
14	13	[M1419W-None]	12314.30	1048.95	238.01	26.90	90.48	12314.30

ARLISS SJSU
Length: 109.7500 In., Diameter: 6.1600 In., Span diameter: 18.1600 In.
Mass 640.7437 Oz., Selected stage mass 640.7437 Oz.
CG: 69.5610 In., CP: 84.5524 In., Margin: 2.46
Eng nes: [M1419W-None,]

RockSim

Step 3: Run simulation.

Rocksim - 2D flight profile

Simulation	Results	Eng
5	4	[M]
6	5	[M]
7	6	[M]
8	7	[M]
9	8	[M]
10	9	[L9]
11	10	[L9]
12	11	[M]
13	12	[L9]
14	13	[M]

ARLISS SJSU
Length: 109.7500 In., Diameter: 6.1600 In., Span d
Mass 640.7437 Oz., Selected stage mass 640.7437 O
CG: 69.5610 In., CP: 84.5524 In., Margin: 2.46
Eng nes: [M1419W- None,]

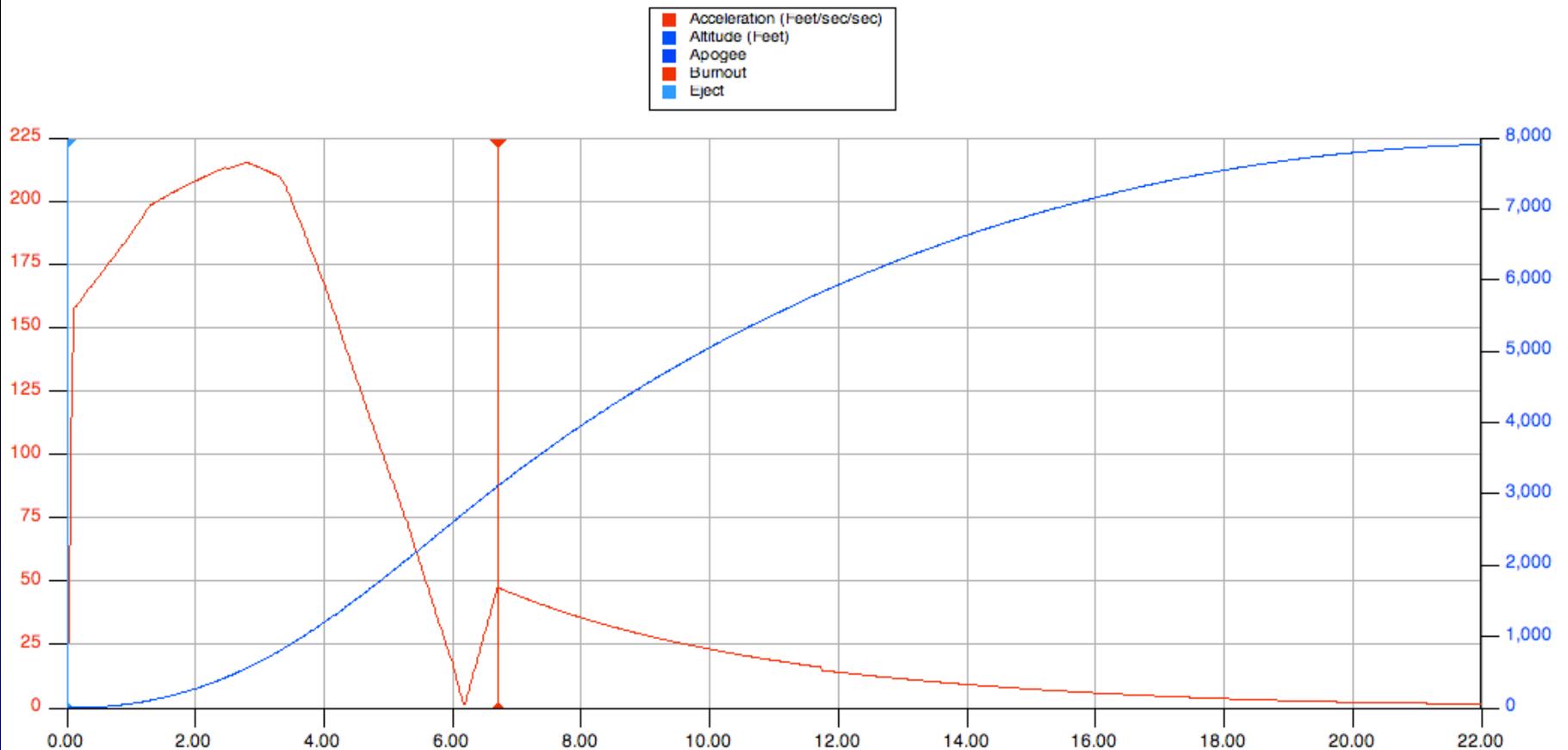
Flight time (Seconds): 292.375
Altitude (Ft.): 3459.4
Range (Ft.): 809.129

Animation time step: actual

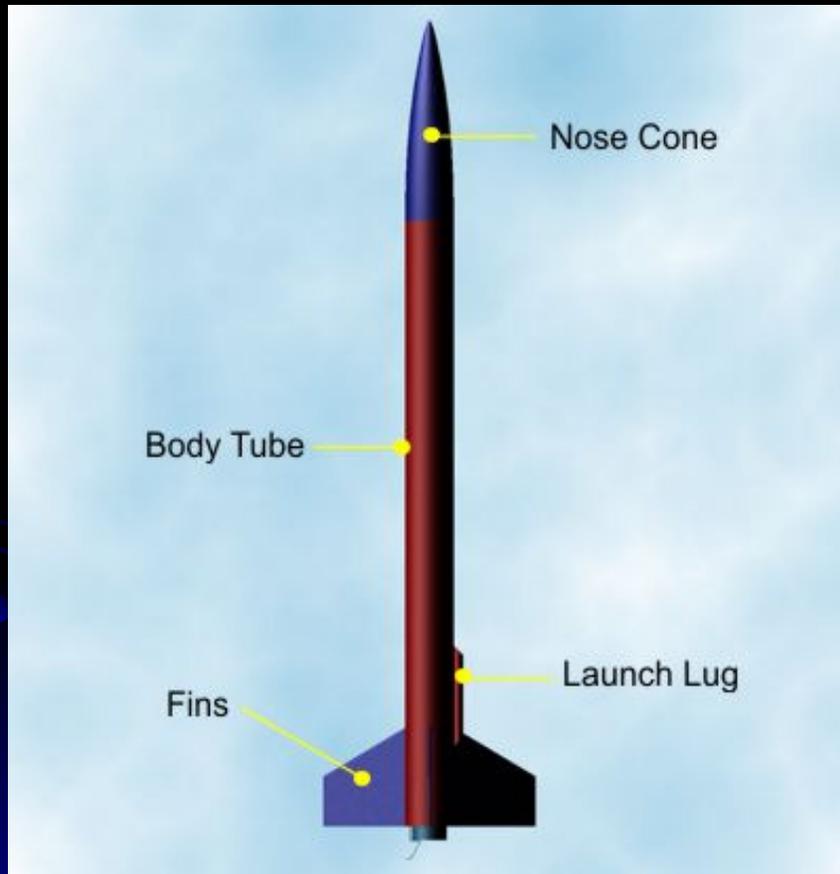
Help... Preferences... Details >> Cancel

Rocksim estimated graph of altitude and acceleration

ARLISS SJSU



Main Parts of Rocket

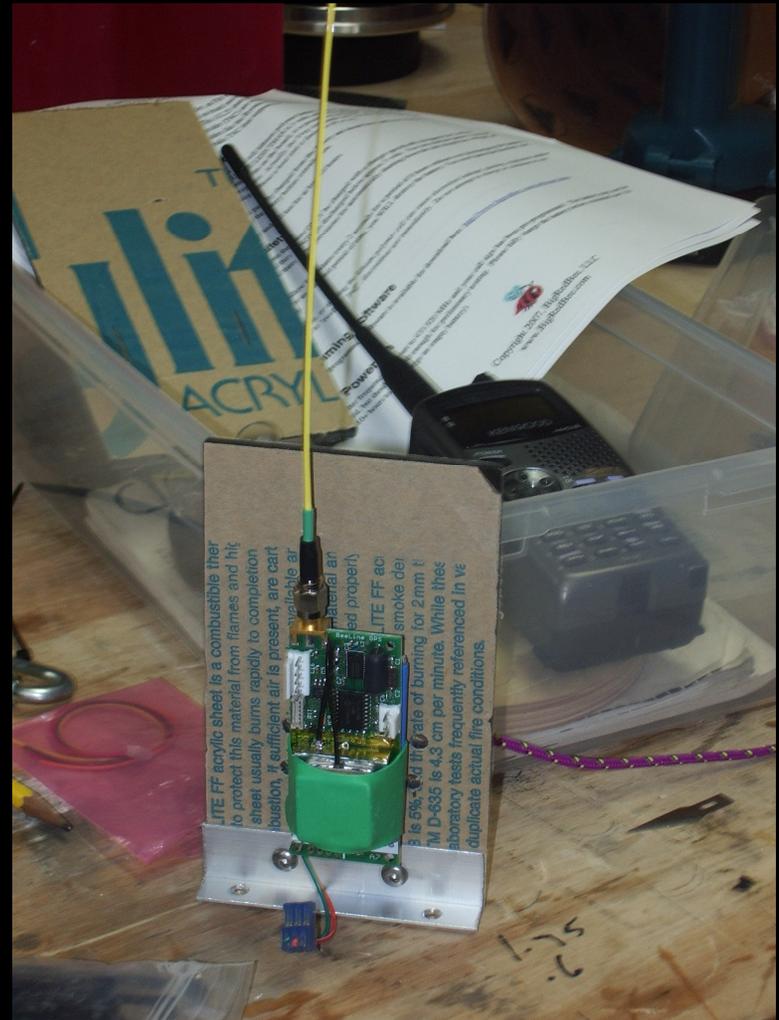


- Nose Cone
 - Parachute
 - GPS
- Body Tube
 - Cansat carrier
 - Electronics Bay
 - Coupler tube
- Booster Frame/Fins
 - Coupler tube
 - Motor



Rocket Electronics

- 1x BeeLine GPS Transmitter
 - Mounted inside the plastic RF-transparent nosecone
 - Transmits data on 70cm HAM radio band
 - Uses the Automated Packet Reporting System (APRS) protocol to communicate with a Kenwood TH-D7A receiver
 - Transmits altitude, latitude, longitude, heading, and speed
 - Range of up to 20 miles line-of-sight
 - On-board memory to store in-flight data

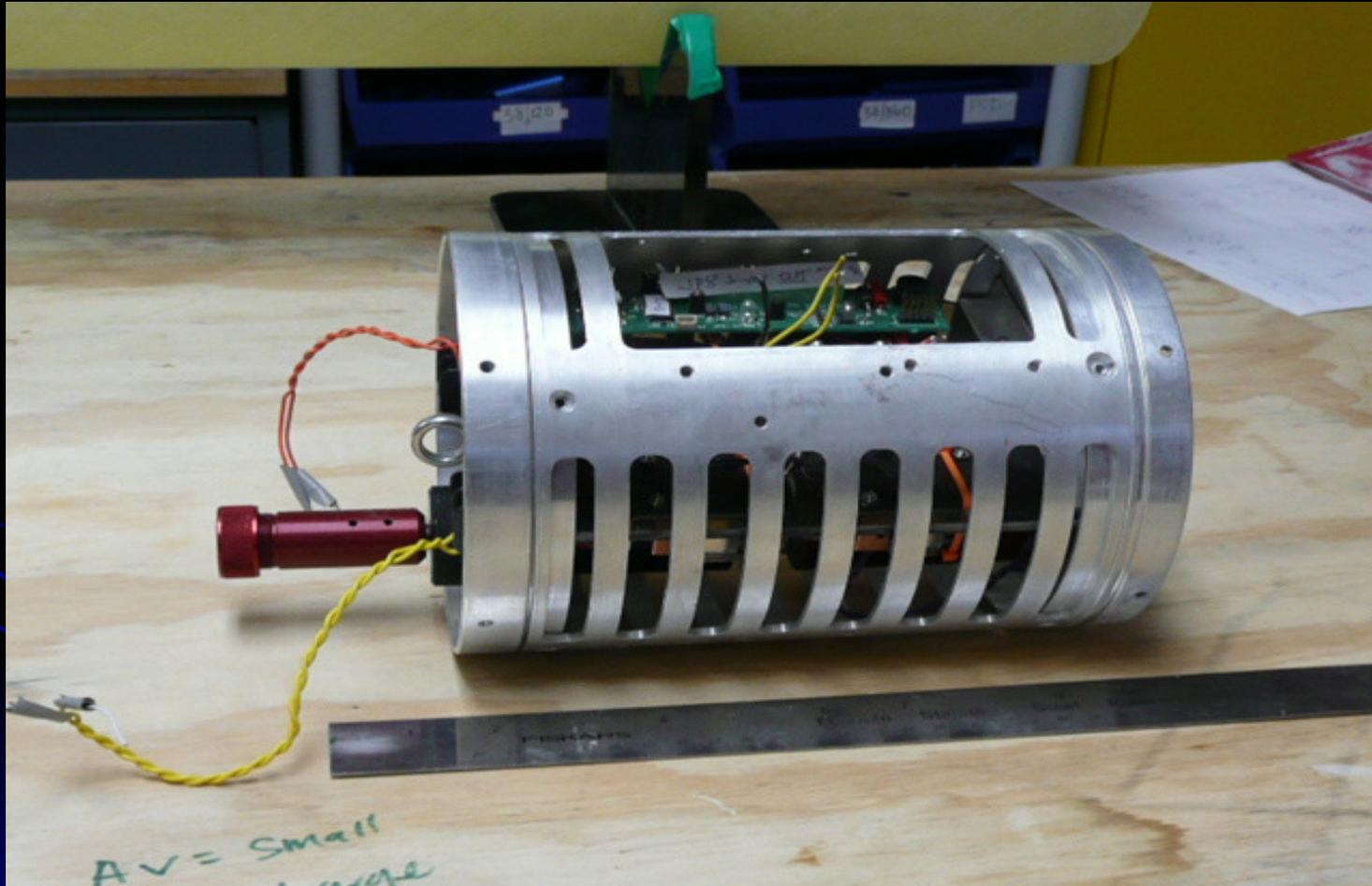


Rocket Electronics

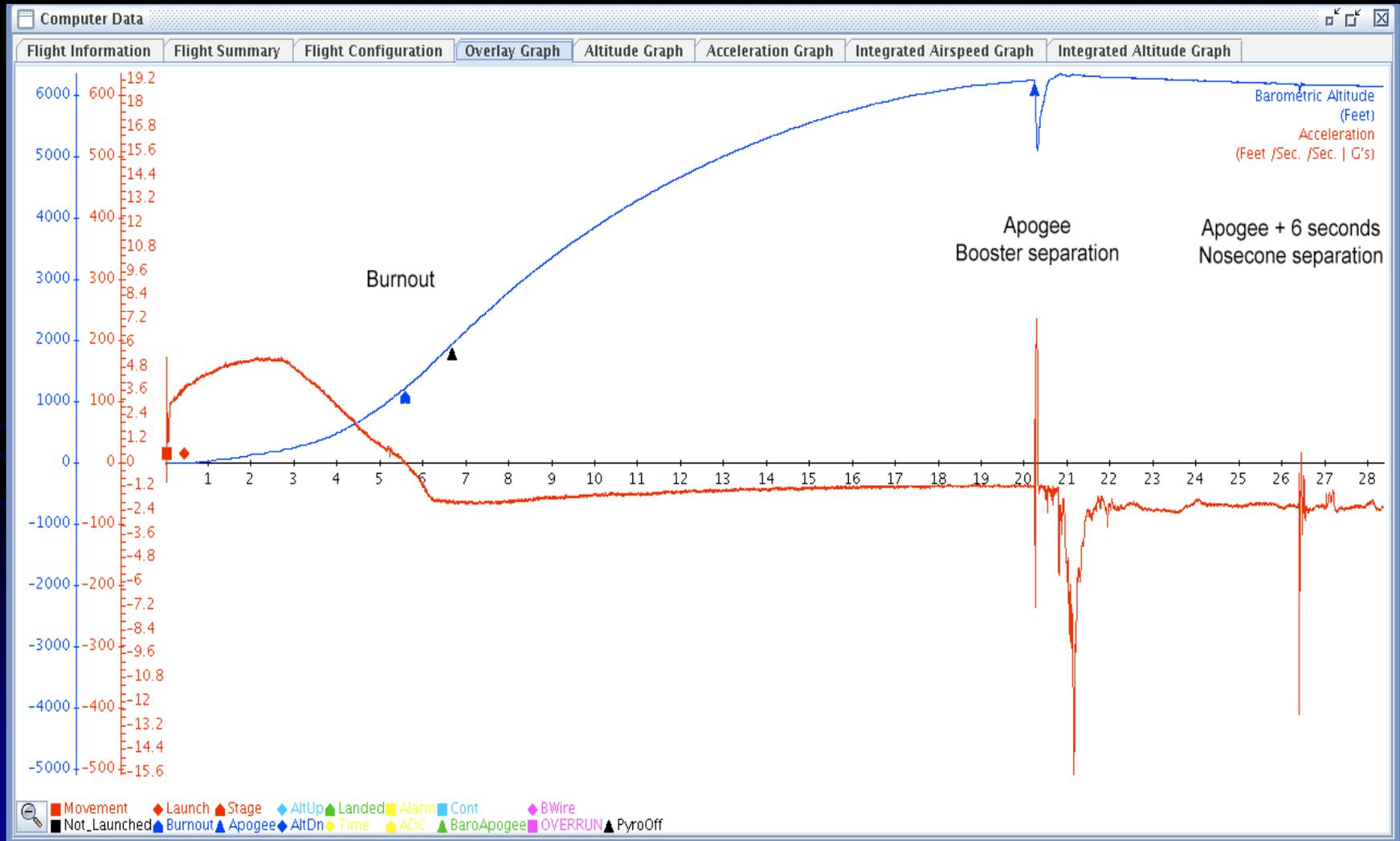
- **2x G-Wiz HCX/50 Flight Computers**
 - Operate simultaneously to provide redundancy
 - Records acceleration and barometric data
 - Apogee is detected via accelerometer
 - Fires main CO₂ ejection system at apogee to separate booster
 - Fires secondary CO₂ charge 6 seconds after apogee to separate nosecone and CanSat carrier.
 - Computers and ejection system are powered by four 9V Duracell batteries



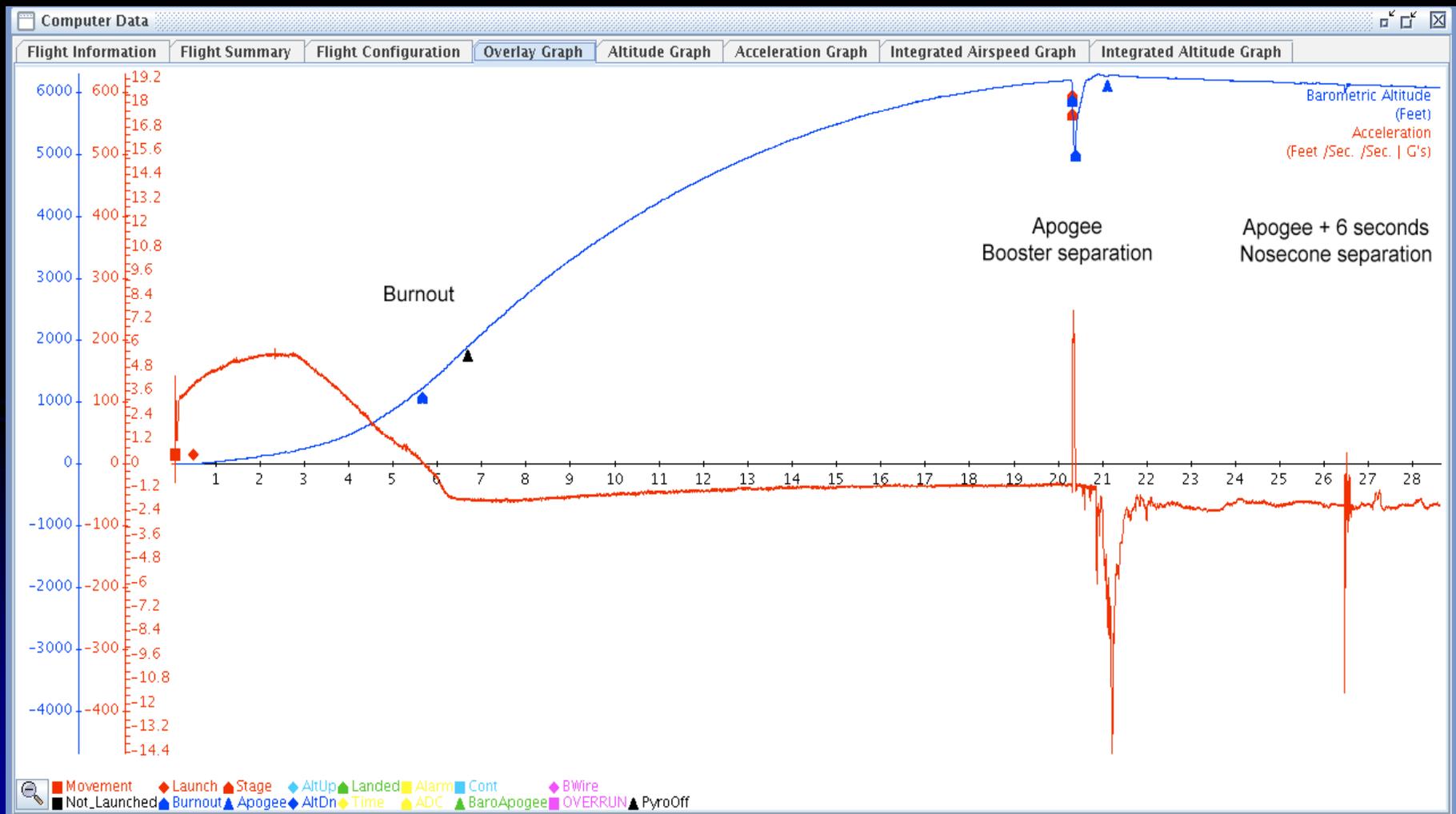
Electronics Bay

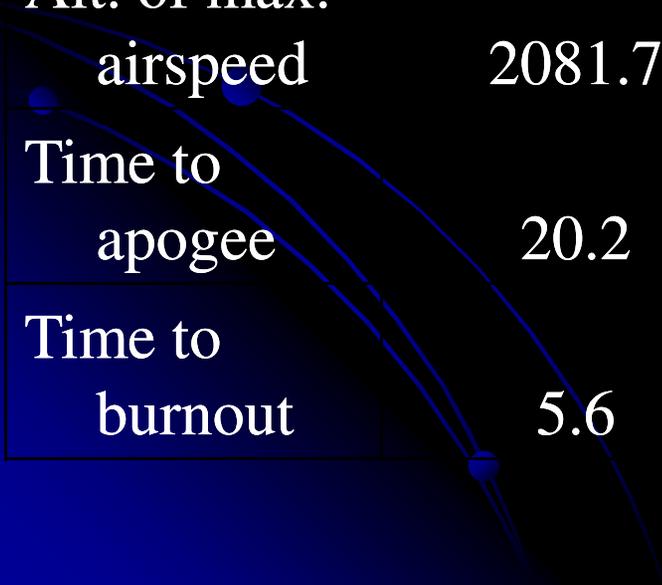


Acceleration and altitude versus time from flight computer 1



Acceleration and altitude versus time from flight computer 2

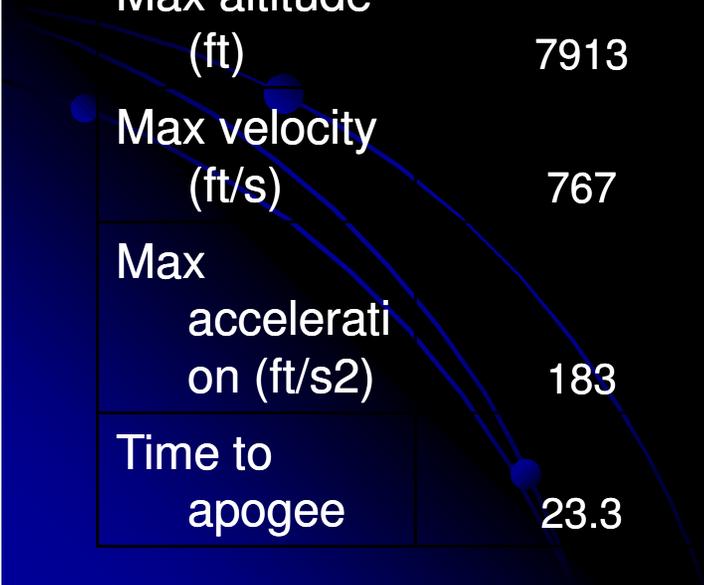




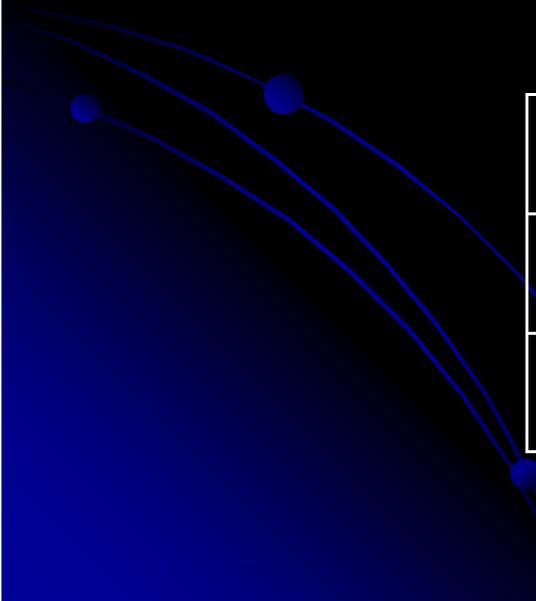
	Computer 1	Computer 2	Discrepanc y
Max altitude	6302.0	6269.0	0.5%
Max airspeed	636.0	675.4	6.1%
Max Mach	0.57	0.61	7.0%
Alt. of max. airspeed	2081.7	2233.0	7.3%
Time to apogee	20.2	21.1	4.5%
Time to burnout	5.6	5.7	1.8%

Conclusions

	Simulation 1	Simulation 2	Simulation 3	Actual	CFD
Weight (lbs)	35 lbs	35 lbs	35 lbs	35lbs	-
Cd @ 500ft	-	-	-	0.092	0.071
Max altitude (ft)	7913	7711	6318	6302	-
Max velocity (ft/s)	767	723	671	636	-
Max acceleration (ft/s ²)	183	172	164	170	-
Time to apogee	23.3	22.8	20.3	20.3	-



Dimensions of the Arliss Rocket



Total Thrust	952 N
Propellant Weight	2650 gm
Burn Time	6.2 s